Year 4 Report 1, 12/20/08-2/19/09

NNSO6AA78G, "Improving water resources management in the western U.S. through use of remote sensing data and seasonal climate forecasts"

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This is a joint project of the University of Washington and the University of California, Irvine (PI S. Sorooshian). It is aimed at utilizing NASA remote sensing data and hydrologic and climate prediction models in a partnership with three operational water management agencies – the Natural Resources Conservation Service, which provides seasonal streamflow forecasts over most of the west, the U.S. Bureau of Reclamation, which has decision authority within the Klamath River basin (where there have been ongoing and highly publicized conflicts over water allocation), and the California Department of Water Resources, which has decision authority for much of the Sacramento River basin. The project leverages heavily from the University of Washington's west-wide hydrologic forecast system (http://www.hydro.washington.edu/forecast/westwide). While the primary focus of this research is on water management, there are secondary benefits for the energy sector, particularly hydropower. This report covers work conducted the University of Washington, and by U.C. Irvine (under contract to UW)

The project consists of seven tasks as follows:

Task 1: Klamath River forecast system enhancements

The existing UW west-wide forecast system will be enhanced for application in the Klamath R. basin. In particular, we will add forecasts points of interest to USBR, and will apply MODIS SCA updating that we have previously tested in the Snake River basin. We will modify the current UW forecast system to a 1/16 degree grid resolution (currently 1/8 degree), to capture smaller drainage areas within the Upper Klamath River area. We will migrate the forecast system so that it can be run at NWCC, with performance monitored by both the UW team as well as USBR Klamath Basin Area Office operational staff.

Status: The snow cover areal depletion curve (i.e., SWE-SCA relationship) was investigated for the Feather River basin. Figure 1 shows this curve during the snow melt season of 2004 (March 1 to June 30). SWE data were averaged from eight California Cooperative Snow Surveys (CCSS) sites, mostly located in higher elevations. SCA data were averaged over the entire basin from MODIS and VIC model output. Of note is the relatively large (~300 mm) observed SWE when MODIS SCA is near zero, indicative of the thick snow that persists in higher elevations towards the end of the snow melt season. In contrast, VIC SCA is much larger at SWE values less than 500 mm, and remains at about 8% even when SWE is zero. The analysis indicates the potential to improve VIC snow simulations, and streamflow forecasts, during the snow melt season.

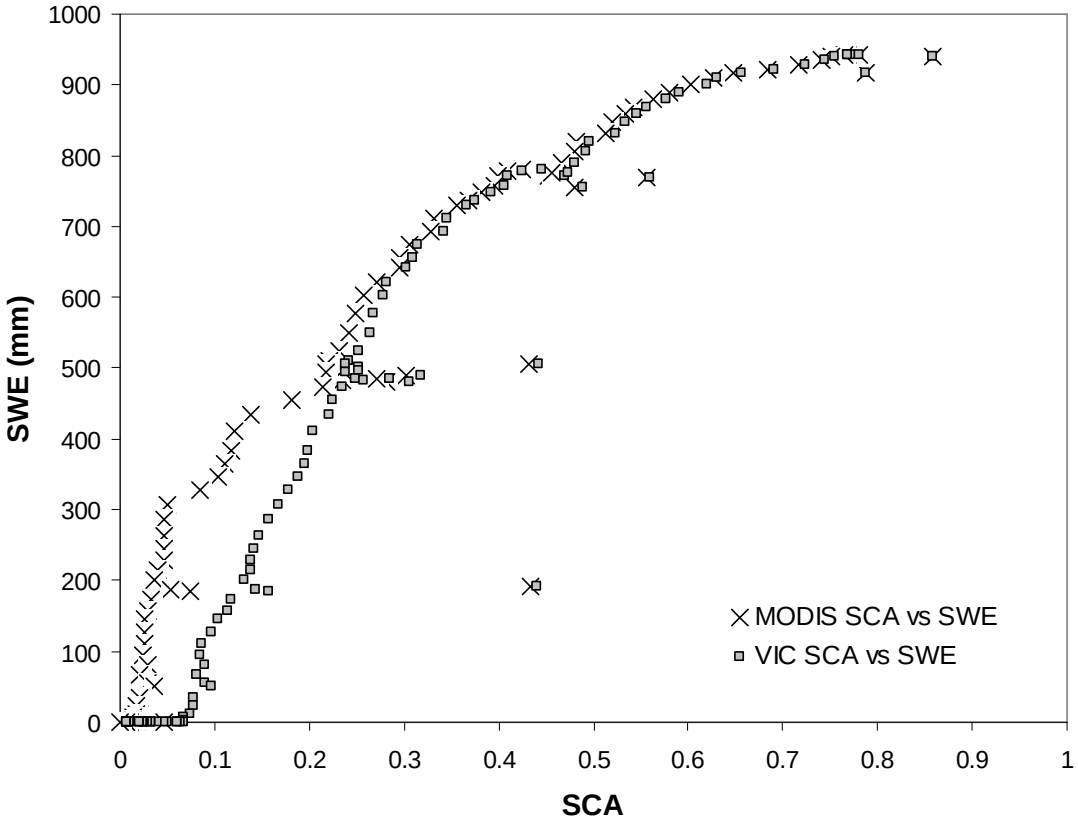

Figure 1: Snow cover areal depletion curve for the Feather River basin during the 2004 snow melt season (March 1 to June 30). SWE data were averaged from 8 CCSS sites. Basin averaged SCA were derived from MODIS and VIC data.

Task 2: Upper Klamath Lake net inflow calculation via remote sensing.

We will interact with USBR and NWCC to develop post-processed forecasts from our west-wide system that will represent Upper Klamath Lake net inflow (i.e., impairment to reflect the effects of crop water use, reservoir evaporation and ungaged local runoff). The primary alternatives to be explored include: a) a statistical temperature index method, and b) satellite-derived estimates of crop water use and of lake surface temperature, coupled with a VIC-based lake simulation. The two satellite products will be assimilated into the VIC nowcasts during the spin-up period to each forecast date. The results will be evaluated indirectly via comparison with derived UKL net inflows.

Status: The impacts of irrigation on Upper Klamath Lake were assessed through a combination of remote sensing and hydrologic modeling techniques. ET estimates based on remote sensing data were used to calculate net irrigation consumption for areas within the Klamath River basin that are irrigated with water from Upper Klamath Lake. Irrigation consumption estimates were then used in conjunction with reservoir inflow data to assess variations in lake water depths. Monthly mean water balance components are shown in Figure 2, where O_{irr} (water withdrawn for irrigation purposes) is set to equal the net irrigation consumption. The water balance simulations illustrate the importance of irrigation withdrawals to lake storage volumes, particularly during the high irrigation season of June to September.

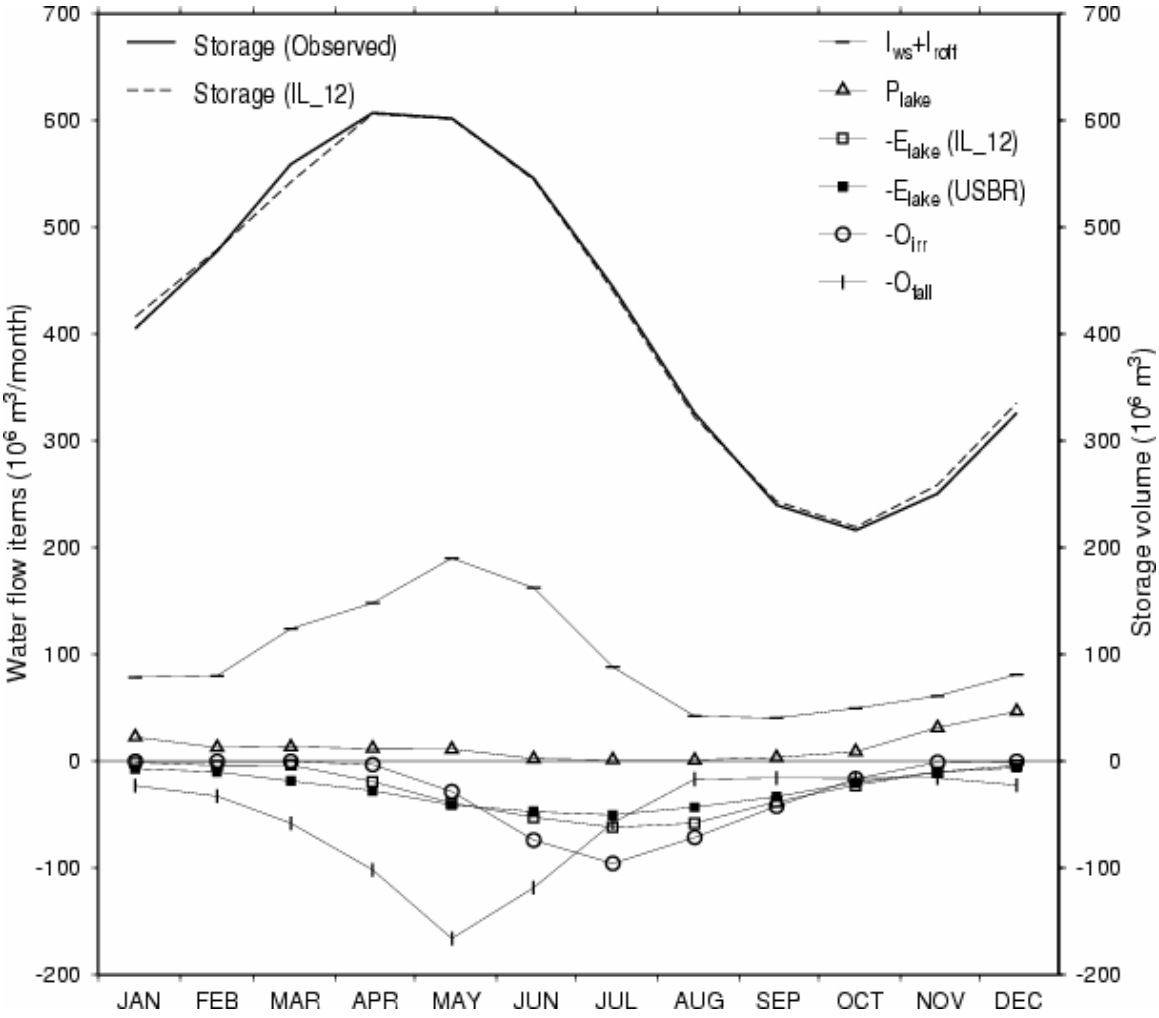

Figure 2: Simulated and observed monthly mean water balance terms at Upper Klamath Lake from 2001 to 2005. Total surface inflows are represented by (I_{ws} + I_{roff}), precipitation over the open water surface is P_{lake}, evaporation over the open water surface is E_{lake}, water withdrawn for irrigation purposes is O_{irr}, and outflow from the lake to the Klamath River downstream is O_{fall}.

Task 3: Forecast system implementation/monitoring for Feather/Sac River basins

Implementation of the UW west-wide forecast system for the Sacramento basin will begin with the Feather R. before expanding to other basins in the Sacramento basin. UCI/UW team members will implement additional forecast points used by DWR, and increase the forecast system spatial resolution (i.e., to a finer grid scale) if necessary. During the first two seasons of the project, the forecasts will run in real-time (parallel to DWR operations) at UCI. Subsequently, modifications in the system required for transition to the DWR environment will be made, and data assimilation algorithms similar to those planned for the Klamath (Task 1) will be implemented.

Status: Improvements in snow simulations due to MODIS SCA updating were investigated for the 1/16 degree VIC model in the Feather River basin. Figure 3 shows basin-averaged SCA and SWE before and after MODIS updating in 2004. At the end of April, MODIS-derived SCA is about 5% of the basin, while VIC-derived SCA is about

15% of the basin. The substantial overestimation of VIC SCA, in turn, causes an overestimation of VIC SWE – a result which is moderated by MODIS SCA updating.

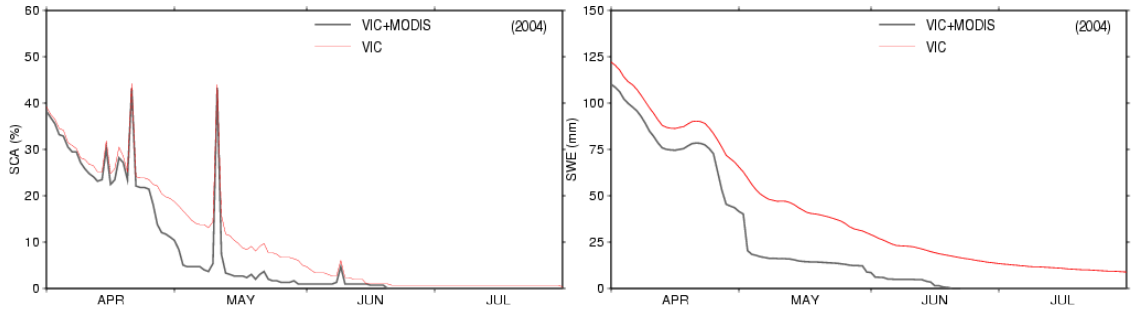

Figure 3: Basin-averaged SCA (left) and SWE (right), with and without MODIS SCA updating, in the Feather River basin from April to July 2004.

Task 4: Forecast impairment in CADWR/SWP basins

This task is similar to Task 2. UCI will establish, in consultation with DWR, an arrangement by which forecasted streamflows will be routed through the same decision process currently used by DWR for its operational forecasts. Either DWR will route the forecasts in parallel with their operational ones, or UCI will obtain the necessary algorithms to do so at UCI. UCI will also develop analogous methods applying to forecast system products that are new to DWR.

Status: Both nowcast and forecast systems continue to run operationally at UCI's CHRS.

Task 5: Forecast communication (Klamath and Sacramento basins)

To facilitate NWCC, USBR, and DWR review of forecast system performance, UW/UCI project team members will prepare summary or explanatory reports for (a) regular, real-time forecast updates, and (b) any upgrades or major changes to the experimental forecasting system, and will host conference calls to interpret the results during the course of the forecast season (probably weekly during the period March 1 – June 1, and less frequently at other times). These conference calls and associated reports will be made available via the web. In addition, during the off-season, UW and UCI will host one-day workshops at USBR's Klamath Falls office, and DWR's Sacramento office, to evaluate forecast system performance, and the means by which forecasts were used in the decision process in the previous season.

Status: Work has continued on the application of MODIS SCA data to DWR's regression-based forecasts in 14 California watersheds.

Task 6: Retrospective assessment (Klamath and Sacramento)

We will undertake a retrospective assessment of forecast system performance in both study areas to serve as the basis for evaluation and modification of the forecast system. To the extent possible given the limited period of record of remote sensing data sources such as MODIS, we will perform retrospective forecasts made in a manner consistent with real-time operation, and evaluate changes in forecast skill due to incorporation of remote sensing data, and ensemble climate forecasts. We will present results of the retrospective evaluation at one or more of the planned one-day workshops (Task 5).

Status: Work has begun on a satellite-based ET product for the Yakima River basin, WA.

Task 7: Transition to operations

In Year 3, before the final forecasting season, UW/UCI research team members will meet with NWCC, USCR, and DWR operational staff to plan permanent migration of those forecast elements that have performed the best into operations. As the final forecast season progresses, the UW/UCI team members will train operational staff and prepare documentation manuals that will enable NWCC and DWR to operate the forecast system independently. Team members will make frequent trips to Portland and Sacramento during that period to troubleshoot and address any complications stemming from migrating the forecast system from the research center to the operational center, until the conclusion of the project.

Status: Work has not yet commenced on this task.